Recent Physical Development

CONVOCATION ADDRESS

BY

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There is no doubt that each succeeding generation is prone to believe that it stands out before all others in the advances in natural knowledge which it has witnessed. But I think the past generation, and even the past decade, can claim more justification than merely this one of customary self-congratulation for considering its period of years an extraordinarily fruitful one in the province of scientific research. More especially is this the case in the special department of physics; and without atttempting anything like a complete review of the recent progress of physics, I wish to ask your attention to a consideration of a few of the most prominent of late physical discoveries. During the last twenty-five years the progress of physics has been so rapid, and discovery has followed on the heels of discovery from such unexpected and surprising quarters, and with such startling novelty, as to be at times almost disconcerting. But when the period of astonishment is over and the physicist has had time to consider the bearing of the latest wonder, he is gratified to realize that, profoundly as the new discovery must modify his previous conceptions, it does not nullify the existing scheme and fundamental basis of his subject. Surely no other discovery was ever revealed to a student of nature which compares in nove ty and importance with the discovery of radioactivity, and the production of that marvellous wizard of matter, radium. Though not a thimbleful of it has yet been produced, so delicate is the apparatus with which we measure its properties, so subtle the mathematical processes through which reason quickly and accurately collates the experimental results, and so vivid the imaginative vision of the Curies the Thomsons and the Rutherfords who read the riddle of the writing on the wall, that, although the first impure radium was only produced seven short years ago, considerations which have withstood the buffeting of experimental cross-questioning for one hundred years have had to be radically altered, and we find that our whole system of the meaning and structure of matter must be rebuilt on newer and larger foundations—surely a sufficiently revolutionary result to build on experiments each made on an amount of matter that would just about fill the eye of a sewing needle. And yet it has been that paradoxical thing, a peaceful and peaceable revolution; for our old theory of matter was all to the good; we cut nothing off it; we only add on. But the new structure is so magnificant a pile that the old building is dwarfed into insignificence beside it; and yet the new had its origin in the old ; and the old in turn is justified by the new. It is the realization of the ever onward and upward continuous growth of physical science that should give to the philosopher his greatest satisfaction.

To the general public, the announcement that some old established scientific theory has been changed, often brings, I fear, an added feeling of distrust of these fellows who deal in technical terms; to the scientifically-trained mind it brings a feeling of elation, for he realizes that decided progress has been made, and that he can tread the recently revealed path for a time with security. This feeling of the layman, that the fact that the scientist has so frequently to change his ground makes his whole fabric rather shaky and his whole scheme of nature rather a fantastic one, is largely due to a misconstruing of the word "theory" as used in scientific work. We observe and know facts; we construct a theory from mental imaginings. And it is too seldom understood that imagination is an essential part of the equipment of any one who would make any advance in the realm of science. Imagination is supposed to be an adjunct of the poetical and artistic genius; the scientist is thought deficient in it, or even better without it, if he has it. But what imaginings of the poet or the painter can be put before those of the man who seeing before him some specks of dull powder pictures to us each formless speck as only the crude manifestation of myriads of invisible small equal particles (the molecules) careering with rash, yet certain, steps; with seeming jaunty abandon, and yet unfalteringly taking their assigned successive places; apparently all free lances, and yet ever obeying the simple laws of their attraction. Farther he makes each of these flying molecules to be a group of smaller dissimilar sprites (atoms), whirling in mazy circles round and round each other, like the planets of a glorified solar system seen through the inverted telescope; he assigns to each the length of his little day and year; he sees their number and their orbits; he follows their conjunctions and their eclipses. And now, not content with that, his magination, only whetted by this first vision, makes each circling atom display itself as a great swarm of thousands of tripping fairies (electrons) their wands tipped with a star of shining negative electricity, formed up in concentric circles, in a nimbus of positive electricity, and treading a kind of stately minuet. Such a theory is not mere fancy, it is based on facts, and is an imagined mechanical model whose behaviour will simulate the performances which our senses reveal to us—a *mechanical* model, that is one requiring the properties with which we have endowed matter, viz., mass, inertia, elasticity, volume, etc. If matter is only a manifestation of electricity, to which view recent investigations point, it may be that we have no right to apply mechanical principles at all. But if the model is useful, we do not care. So it must be remembered that when we speak of the theory of matter and say it is made that matter of molecules, and they of atoms, reacting on each other with certain forces, we do not mean that our faith is pinned to this as a reality; we only mean that it is a useful model of a universe which *might* give the phenomena we observe, and we test it to see if it *could*, and further, if it will suggest other properties to be looked for. If it satisfies these tests this imagined model we call our theory, and find it invaluable to concentrate and focus thought, to store away and card-catalogue known properties in a form easy of access, to suggest new developments, and to save the brain trouble in following complicated and ramifying lines of thought and reasoning. Actual molecules may exist, but for our purpose they need not; we are satisfied so long as matter behaves as if they did exist. When we change a theory then, we only alter the mechanism of the model in some details. But the old one taught us how to make the new.

In considering the advancement made in these few years the question has arisen whether the intellectual ability of the modern being is markedly greater than that of his predecessor of a few generations and centuries, or whether it is a case of greater mental activity and concentration; but, more probably, it is merely the result of the many mechanical aids to, and substitutes for, the senses, which we have at our disposal in the laboratories. With the camera, the bolometer, and the coherer, waves of many kinds besides those the eye sees are confidently revealed to us. The electroscope detects quantities of electricity of surprising minuteness. The mechanical substitutes for the ear are infinitely superior detectors of air-motion. And so on through the list. It is probable therefore that the aid which these instrumental appliances put at our disposal accounts largely for the rapid growth of scientific knowledge, by the stimulus they give to intellectual activity, so that formal reasoning is made easier and its conclusions tested quickly and accurately at every step.

It is now about a third of a century since Clerk Maxwell postulated the existence of an elastic ether with properties something like those of a calves-foot jelly; this ether was to fill all space and even the pores of all matter. This was his mechanical model to explain electricity. Electrification consisted in a distortion of this jelly. Following out an abstruse mathematical treatment of the behaviour of such a substance, he found its properties would agree well with known electrical facts; but, better, the hypothesis predicted that any distortion set up in this ether, would travel outwards from the centre of disturbance in waves, like ripples sent out from the disturbance of the water in a pond by a falling pebble; and, most startling of all, that these waves would travel with the exact velocity of light. This was a prediction of the model. It fell to a German physicist, Hertz, about 1888, to actually set up such waves and measure their velocity, and he found that Maxwell's predictions were verified. Such a verification made the postulation of an elastic ether with the properties Maxwell assigned to it more than a mere guess, it made it a theory, and light became at once but a phenomenon of electricity, the rythmic pulsations of the universal ether. If these vibrations are rapid enough to affect certain nerves associated with our eyes we call them light; if still faster, they do not affect our senses, but do affect a photographic plate; if somewhat slower, they affect certain nerves associated with the skin, and we call the sensation heat; if still slower, we have no nerves which they affect, and so we do not perceive them, but Hertz and his successors made what we might call *mechanical nerves* in the laboratory which the waves do effect and so are perceived; these are the waves used in wireless telegraphy. It is a short step from this academic testing of an hypothesis to its commercial application when verified. The ether is all about us and belongs to us all, and all that was needed in order to utilize it for the purpose of telegraphy was to elaborate Hertz' apparatus on a larger scale so as to set the ether in energetic vibration at one place, and other apparatus to receive these vibrations when they reach another place. With this stage of the development the name of Marconi is prominently associated. Disturbances set up in the ether at Poldhu in Wales travel along across the Atlantic, and the coherer the mechanical eye, sees them at Cape Breton. It is true the disturbance received at Cape Breton is too weak to be relied upon yet for commercial work, but it is only a question of months before the remaining mechanical difficulties are solved. For distances up to two hundred miles they are already completely solved. Thus have the philosophic and seemingly fantastic dreams of the bookman become the common heritage and the common-place of the man in the street. The heart of the trackless desert is the only place to which the capitalist can now go to escape the cares of business.

To turn to a later development of physics, and one which reached the shop-stage sooner. In 1895, a startling announcement came from Professor Röntgen, of Würzburg, which to the layman brought the sensational statement that one could see through opaque objects, and that one's very own bones and even one's heart beat were to be revealed to the curious and the gossip, and that secrets were to be no more. To the scientific student its import was even more astonishing; for these X rays, as they were termed, were not light (for they are not refracted by a prism); they were not charged particles of matter (for a magnet had no influence on them); they were veritable unknown rays, and so X rays. The word *ray* has come in this sense to be applied to anything which travels out in straight lines in every direction from a central source. Before looking at the explanation now given of these Röntgen rays, it will be well to go back and see what had gone before Röntgen discovery. For it needs hardly to be mentioned that a marvellous phenomenon of this kind does not come like a bolt from the blue, or like a Venus full-grown at birth; but that it is the culminating point in a long series of, perhaps seemingly unimportant, investigations by patient, perhaps unheard of, workers, to whose unsung labours the glory is partially due that comes to a Röntgen, but whose only reward has been the satisfaction of helping to steal from nature her secrets, and whose only desire the possession of appliances to carry on their unequal task.

Many years before, Sir William Crookes had found that when a vessel with two wires sealed into it was exhausted to a very high vacuum, and an electric discharge sent through it, "rays" travelled out from the end of the wire which was negative, that is, the cathode, the wire at which the current goes out of the vessel. These cathode rays, that is, something travelling out in straight lines from the cathode, were made evident to the eye, by the fact that where they hit the glass wall of the vessel they made it brilliantly fluoresce, that is, glow without heat; and it was observed that the patch of fluorescence could be moved by bringing a magnet near the tube. It was found that these and the other phenomena observered in connection with the cathode rays could be coördinated by supposing that the rays were small particles of matter shot out from the cathode with terrific velocities at right angles to the surface, each particle carrying a charge of negative electricity. These rays did not get out into the room, as they cannot pass through the glass wall of the vessel. Had Sir William happened to have lying near one of these tubes giving out cathode rays, a box of photographic plates in their ordinary protective covering, he would have found, what it fell to Röntgen's lot to find, that his plates were all fogged. This would not please one in all circumstances, but it would have told that there were other rays given out besides the cathode rays, rays that would penetrate the glass walls and the cardboard box and still affect, as light does, the photographic plate. These are the X rays, and are given out wherever there are cathode rays, and from the place where these rays strike any obstacle in their path. The X rays and cathode rays have many properties in common: both affect a photographic plate; both change air from being an insulator to a conductor of electricity; both travel in straigh lines; etc. But they are not the same: for the cathode rays are easily absorbed by matter, but the X rays not; the cathode rays are deflected by a magnet, but the X rays are not. Light, as I have said, is now accepted to be an electromagnetic manifesta tion of the ether; it is a series of successive to and fro motions of electrical disturbances in the all-pervading ether, travelling like the waves in an ocean. Now if we have a negatively charged particle flying through space, and it were suddenly stopped, we should have an electromagnetic disturbance set up at the spot where it was stopped, and this disturbance would travel out from that spot in all directions just as light does—but, we should have only half of one of the long series of waves which make light; that is, the *to* without the *fro*, and no repetition—a pulse in the ether, like one splash in the sea. This is an X ray; it is an electromagnetic disturbance in the ether, and differs from light, and the waves used in wireless telegraphy, as one awful crash of the cymbals differs from the sustained organ note.

The curative properties of X rays, from which so much was at first hoped, remain doubtful; but their aid in surgery is so valuable that no well-equipped hospital is without them and so they have taken a place at once in our every day life

Discovery from this time went on with swift and almost unfaltering foot. The X rays cause bodies to fluoresce; at once in various laboratories men were at work on fluorescing bodies to see if they sent out these rays. They did not find that; but they found something more unexpected. Mon. Henri Becquerel, in 1896 (the year after Röntgen's discovery), discovered that the metal uranium, or any of its compounds, sent out rays, generically called *Becquerel* rays, which affect photographic plates, pass through opaque bodies, make air conducting, cause fluorescence in suitable bodies, etc. Becquerel at first thought that this was due to phosphorescence, that is, the after-glow due to exposure to sunlight; but he soon found that this radioactivity was present in uranium that had never been exposed to sunlight; that it was quite immaterial whether the uranium were in metallic or combined form, as a solid or in solution. It was an inherent, *spontaneous* action; he could not stop, start, or in any way control it; and it went on from day to day with no decrease in intensity. Next, similar effects were got from thorium. Then began a systematic search by Mon. and Mme. Curie of Paris among all kinds of matter for substances possessing this property. It was found most prominent in the mineral pitchblende from which uranium is extracted, and more intense than would be expected from the amount of uranium present; and Mme. Curie, and those working with her, soon found that by treating the mineral chemically, it was possible to isolate something still more powerfully radioactive; and in the end they got three new elements, radium, polonium, and actinium. Of these radium is the most active, and nearly two million times as much so as uranium, weight for weight. The amount of labour and skill required to extract enough radium to be visible to the eye is prodigious; only $\frac{1}{10\,000\,000}$ % of pitchblende is radium; it is rarer than gold in the ocean. One ton of pitchblende produced $\frac{1}{7}$th of a grain of radium. With this tiny particle of the new substance the Curie's, with wonderful skill, aided by the most ingenious and accurate instruments, determined its atomic weight and its spectrum, and demonstrated its right to be called an element.

Later investigations of these Becquerel rays have shown that, whatever their source, they are of one or more of three types, called alpha, beta, and gamma rays. The alpha rays are positively charged material particles ; the beta rays are negatively charged particles, like the cathode rays ; and the gamma rays are pulses in the ether like alpha rays, and produced by the electrical disturbance set up in the ether when the charged alpha or beta particles are shot out.

Then followed a series of remarkably brilliant experiments by Prof. J. J. Thomson and his school in the Cavendish laboratory of Cambridge University. He measured the electrical charge on each of these alpha and beta particles and found it to be the same as that carried on an ion in electrolysis ; he measured the mass of each particle, and found that of the alpha particle to be of molecular dimensions ; and astonished the world by proving that the mass of the beta particle is 1000 times smaller than that of the smallest atom, that of hydrogen, which the chemist, with what seemed the extremest stretch of the scientific imagination in the direction of smallness, had postulated. With one sweep the atom, the uncuttable, was swept away, that firmest prop of chemical theory which had guided the chemist for a century, and seemed so firmly fixed as a law of nature. But Prof. Thomson did not stop here ; he showed that all substances which gave off a cathode ray or beta particle, gave off exactly the *same* particle, that is, that the particle of matter shot off from the cathode in a Crookes tube, whether it was shot off from copper, aluminium, or any other metal, was identical in properties with the beta particle sent out from radium, uranium, etc. Thus the dream of the Alchemist that all matter was one, with the same constituent parts, and that accordingly one kind of matter could be transmuted into another, was at one stroke a reality. But the end was not even yet—if there is one thing more than another that has seemed to be beyond cavil as a physical law, it is the so-called Law of the Constancy of Mass, that you may heat a body or cool it, magnetize, electrify, expand, contract, evaporate, solidify, liquefy, combine with other substances, it ever *weighs* the same ; and yet a German physicist, Kaufmann, has shown that the mass of one of these beta particles varies with its speed. Thomson measured also the speed of these particles, and found it for the alpa particles to be about $\frac{1}{20}$th.

that of light; whereas the beta particles move much faster, and some of them have almost the inconceivably rapid velocity of light. It is instructive to think for a moment of the curious swings of the pendulum in scientific theory-building. As far back as the Greek philosopher Democritus we find a wild guess of the possible existence of hard particles, inconceivably small, moving with inconceivably great velocities. Lucretius speaks of the beauty of this conception; and down to the days of Newton the minds of men were enamoured of its simplicity and daring. But it was only a blind guess, with no good reason for its existence or acceptance. In the hands of that master-mind Newton these corpuscles were used to explain the phenomena of light, and by his commanding genius Newton was thus able to retard the progress of the study of optics for a century. When at last the wave theory of light slowly forced Newton's theory to be abandoned, now 100 years ago, what self-satisfaction the modern physicist felt in pointing to the absurdity almost of the conception of these little corpuscles of meanest magnitude flying with fiendish velocities. And now here we are again forced to accept the fact of their existence; Newton was only wrong in supposing that they caused the sensation of light; they do not do that, but they have properties even more wonderful.

To return to the experiment of Kaufmann, that the mass of the fast flying beta particle is greater than that of the slow one. This ushers in another change in our scientific theories, which at first sight almost upsets our faith in scientific verity. It means that matter as such disappears, and becomes only a manifestation of electricity. It means that instead of considering the beta particle a little piece of matter with electricity on it, we must consider it quite the reverse, a little stray wisp of electricity having mass (or being what we call matter) merely on account of its motion. Matter is but the impression we receive when certain little bits of electricity move, and has no existence apart from that motion. Thomson has shown mathematically that, for all velocities smaller than a tenth of the velocity of light, the mass acquired by the particle is independent of the velocity, but that for velocities greater than this the mass increases with great rapidity; and this is quite in agreement with Kaufmann's experimental results. It is hard to take in at first this tremendous change, but it looks as if it had to be done. Matter then, as such, disappears from our catalogue of fundamental conceptions, and becomes but one phase of the many which electricity presents, among them being magnetism, light, radiant heat; and we fondly hope that the future will bring into the family that present scientific outcast gravitation. But one must not conclude that we are measurably nearer the answer to the riddle of the universe; we have only explained many things in terms of electricity; but what is electricity? The best answer seems to be that of Professor Larmor, that a negative corpuscle is a centre of strain in the universal ether, which like the little cyclonic gust by the house corner is quite free to wander at will through the stagnant ether. What positive electricity is, is far from being so satisfactorily answered. Groups of these strain-centres gather together along with positive electricity in a sort of Dervish dance about each other, like satellites around the sun, and we have the atom of Dalton and the chemist; a group of these atoms of the same or different kinds constitutes a molecule; and a complex of these molecules constitutes a lump of what we call matter.

The principle of the spontaneous disruption of radioctive bodies, that is, of the continual breaking down of a fraction of all the atoms of radium, uranium etc., and the hurling off of tiny fragments into space, and the consequent decay of the parent body, is the result of another brilliant series of investigations, inaugurated by Prof. Rutherford of McGill University, who almost at the very beginning of his career has made a lasting name for himself in the realm of science. He discovered that radium was continually throwing off from itself a gas; he called it the "radium emanation." This emanation is, like the parent radium, also radioactive, that is, is giving off alpha and beta rays; hence, *ipso facto*, it also is breaking up and decaying. The product after the fragments are hurled off, is a fine powder deposited on all surrounding objects; this deposit is again unstable and radioactive and breaks still farther down. Rutherford has followed these stages with brilliant success, and one of the most startling of the results of the work is that one of the products of the breakdown of radium emanation is stable and non-radioactive, and a well-known element—the gas *helium*, found by Lockyer to be present in the sun (and hence its name), and later found in certain minerals in the earth. Here then what the Alchemist brooded over, and gave his best years to, to end only in heart-breaking failure, the changing of matter from one form into another, the "transmutation" of matter, this Rutherford's work shows to be continually going on before our very eyes. It is true that we have not found the "philosopher's stone," whose possession the alchemist strove for, that with it he might purge the base metals of their dross, and start them on their pilgrimage to the higher and nobler forms. But if we cannot cause the transformation, nor in the slightest influence the action when we find it, it has at least been allowed to us to know that it exists, and to see the throes of death and of life of a few of the elements. It would take us too far to go into these changes in detail, but just as helium is descended from radium emanation, and that again from radium, so radium itself is the child of uranium; and it seems not improbable that another descendant from radium emanation may be found to be lead. What other family relationships of this kind the future has in store for us, it would be vain to guess; but it is surely more than a mere coincidence that the natural grouping of lead and silver, gold and copper, platinum and iridium, etc., in mineral beds is so commonly found, when chemically it would not be expected.

In studying these substances uranium, thorium, radium, actinium and polonium, some of whose atoms are continually exploding and sending off into space the little fragments of two sizes we called alpha and beta rays, the most noticeable thing is, that it is an explosion beyond human effort to change in the slightest. Neither the heat of the arc-light nor the cold of liquid air, neither a pressure of tons to the square inch nor a vacuum, neither fusing nor dissolving, nor anything that the chemist or physicist can do, will in the least change the number of atoms exploding per second, nor start nor stop the process to the smallest degree. It is a spontaneous process, and no other element but the five I have named is known to possess the property.

The practical value of these wonderful discoveries it is yet too soon to measure. It was hoped that bacteria and diseased tissue, as in cancer, could be curatively treated by the bombardment of the hail of these little fragments of matter, but the result of trials is not entirely favorable. We can not turn copper into gold, nor lead into silver, and there is no demand for helium when radium does turn into it. But we are only in the very infancy of the subject, and who dares predict that even the study of radioactivity will not lead to important changes of some mode of living and activity.

One other phase of radioactivity and I have done of this cursory sketch of modern physics. The alpha particle I have said is of moderate size, that of an atom or molecule, but its velocity is tremendous. If such a bullet is brought to rest by striking an obstacle, it ought to develop a relatively enormous quantity of heat This is found to be the case ; a mass of radium is much warmer than surrounding objects, due to the bombardment of the outer layers by the alpha particles from the inner layers. Now a small quantity of radium is found to exist in all matter, and the presence of large amounts of helium in the sun indicates large quantities of its parent, radium, there also. This fact has profoundly modified our explanation of the heat of the earth and sun. For fifty years there has been a keen dispute between the the geologist and the physicist, as to the age of the earth ; the geologist, with the biologist, wanted thousands of millions of years for his geologic eras; the physicist, on the other hand, said the earth was a cooling sphere which was once in a molten state, and that it was probably only 25,000,000 years, certainly not more than 100,000,000, since it was a sticky, white-hot mass, and beyond the ken of geologist and biologist. Now we find the most poverty-stricken rock, when measured by its possession of radium, gives out enough heat through the bombardment of its alpha particles, to more than supply all the daily radiation of heat from the earth ; and, consequently, that the geologist can have practically all the æons of ages which he desires, being only limited by the time required by the great-great-grandfather of all matter to break down into the present forms. Similarly there have been various theories to account for the heat of the sun, which he has been pouring out to us for ages ; we have had the theory that it was due to the sun's gradual contraction, and again that it was due to swarms of meteorites, or shooting stars, colliding with it. But now we have only to assume that a very small percentage of the sun is radium, to account for its continual production of heat. Thus has the knowledge gained from the behaviour of a few granules of a dirty grey powder profoundly modified our whole conception of the cosmogony. But the physicist takes all this change of his cherished notions kindly, and steps forward more confidently,

"Not clinging to some ancient saw;
Not mastered by some modern term;
Not swift nor slow to change, but firm:
And in its season bring the law."

In conclusion, I want to make a plea for the spiritual right of research for research's sake, though I think that the discoveries which I have just described will justify it even from a commercial stand-point, which is apt to be the only criterion these days. It was from a piece of purely speculative mathematical analysis that Clerk Maxwell was able to prophesy the possibility of wireless telegraphy, and to predict the velocity of propagation. It was while studying the passage of electricity through a vacuous bulb, a study that the type of capitalist with no eyes or ears beyond his ticker, would have considered as the harmless hobby of a hopeless, bespectacled, dry-as-dust professor, that Röntgen discovered the X rays, whose value to the surgeon is now so frankly admitted. It is well then not to forget that the hobby and toy of the theorist today is the heritage and tool of the layman tomorrow. This fact has never been appreciated by the English-speaking peoples as it has been in Germany; and, as a consequenee, the strides that country has made in commercial activity have been largely at our expense.

You have heard much lately of the necessity of embarking in our own country on an extensive plan of education in technical departments. It is only those who *will* not, that cannot see that, in our province especially, the need for technical education is imperative and immediate. It is given to every country, as to every man, to have once in its time an opportunity for splendid development; to us that opportunity has now come. Nor will it wait for us; if we are to reap the benefits of the time we live in, and the natural resources Providence has made us caretakers of, it is now that we must set about it. If we do not, others will come and quickly take it from us. I cannot believe that we shall prove so unable to see our chance. It is our boast here in Nova Scotia that we have provided more than our share of the brains of this Canada of ours; we have given her many of the ablest of her statesmen, of the finest ornaments of her literature, her bench and her pulpit; let it be ours also to provide her with the managers of her railroads, her mines and her manufactures. Is it not a disgrace to us that such men are now imported? Is it not our duty to provide means for the education of our own ambitious youths to fill these places? Or have we lost confidence in ourselves, and are doubtful of our powers? There can be no question of the commercial aspect of the problem; other countries with far inferior resources have put that point beyond doubt. The money spent in endowing our laboratories and libraries will return in double measure in the quickening of our commercial activity, and the consequent increase in our wealth and prosperity as a country. Our City Fathers and Board of Trade leaders are seeing the necessity of making an effort to bring manufacturing concerns to this city to stimulate its business interests; I wish that they could as clearly realize that financial support from the city to an institution in their very midst, doing the good work that Dalhousie is doing, would be a vital factor in the certain advancement of such industries.

Again is it not a disgrace to our Maritime Provinces, whose inheritance of the finest fishing wealth is quite unequalled, that there is not a professorship of Biology endowed in any of our colleges? The requirements of fish-culture make it an obvious demand, and Dalhousie will be glad to make a proper use of any funds which the captains of the fishing industry will put at our disposal.

I am afraid that many are making the hopeless mistake of confounding Technical Education with that received in Trade Schools, or again with what is called Manual Training, or consider it but a superior form of these. The man who is manually trained is much needed, but still he has trained only his hands; the man who has a proper technical training has his head trained. His is a rigorous and exhaustive education in the deep theoretical foundations of his profession, and his place is to conceive and originate those methods which the product of the manual training schools are at his call to carry out. To confound the two at this time, when it is to be hoped steps will be taken for the furtherance of technical education in these provinces, is a serious mistake; for if we are not to do the thing rightly, let us not do it at all. It is not a capstone to be put on the high school, or normal school, or manual school system; it is, instead, on the same footing as our university work in liberal arts, and the first two years of the work are identically the same. In these two years the technological student must get his training in pure science, which underlies all its applications ; and it is the need for improved facilities for teaching pure science that stares our universities in the face, and to meet this need is the least that can be considered their share in providing opportunities for a proper technical education.

It is in this connection finally that I wish to call your attention, whether as Governors, colleagues, or friends of education and of the College, to the fact that in helping forward the cry for technical education, you do not forget that the pure sciences, as the parents and fountain-head of technology, must be advanced, not *pari passu* with the technological studies, but in advance of them. It is a great drawback that our laboratories of physics and chemistry are so ill-equipped for the work they ought to be now doing. We in Dalhousie have least cause to complain in that respect; but the rapidly growing demands for lecture and laboratory classes in physics and chemistry have at the present moment entirely outstripped the growth of our facilities both in rooms and equipment; and it is a pity that the friends of this college stand by and see a work of this kind which cries out for aid, not have it, and that whether you measure its service by the necessity for a proper scientific training for the average college bred citizen, or by the material and monetary value which would accrue to the life of the country. The work that has been done in the cramped quarters—so-called laboratories of this college. with a meagre supply of apparatus, some of it decrepit and old-fashioned, by those professors who have toiled day and night for the college (I need mention only the names of Professors MacGregor and E. McKay), speaks volumes for their native ability and resourcefulness, and their devotion to the ideals of pure science.

A university worthy the name must be ever a beggar ; it cannot play its part in the advancement of civilization and be self-supporting ; it must be the worthy object of the willing charity of the community which it serves ; of it also must be asserted—

"The poor always ye have with you."